Biological Evaluation of the Willis Lumber Company

White Pine Plantation in Adams County Ohio

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TABLE OF CONTENTS

Purpose and Need:

The Morgantown Field Office (MFO) received a request from Ohio Department of Natural Resources (DNR), Division of Forestry to evaluate pine bark adelgid (PBD) on several white pine plantations in southwest Ohio. This request came from the local service forester Tim Wilson who was concerned about the health and condition of white pine stands in his area. The MFO was compelled to proceed with the evaluation since this appeared to be a "landscape issue" involving white pine in various areas throughout southwestern Ohio, on many different ownerships on both public and private lands. The MFO feels that this evaluation will help make the case for active forest management of eastern white pine throughout Ohio.

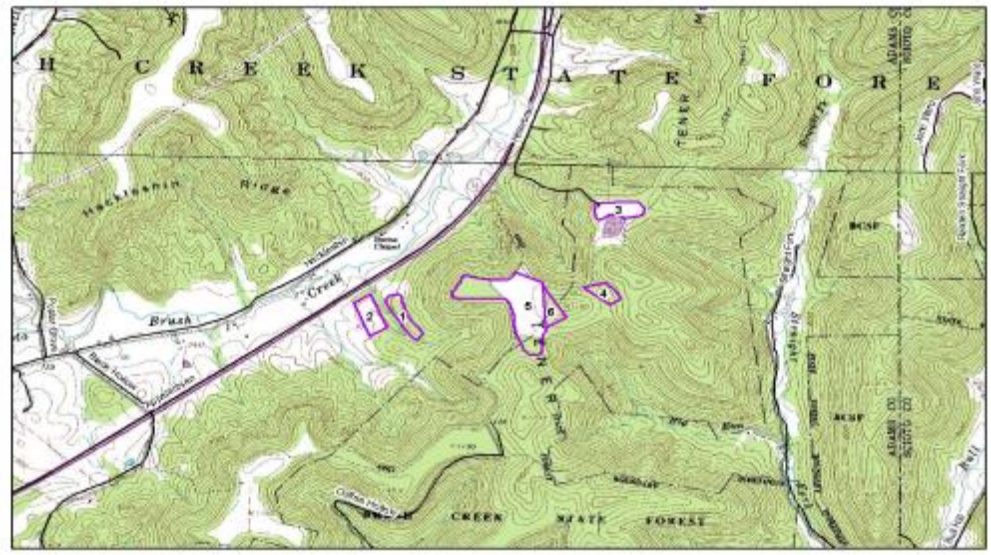
Project Location/Description:

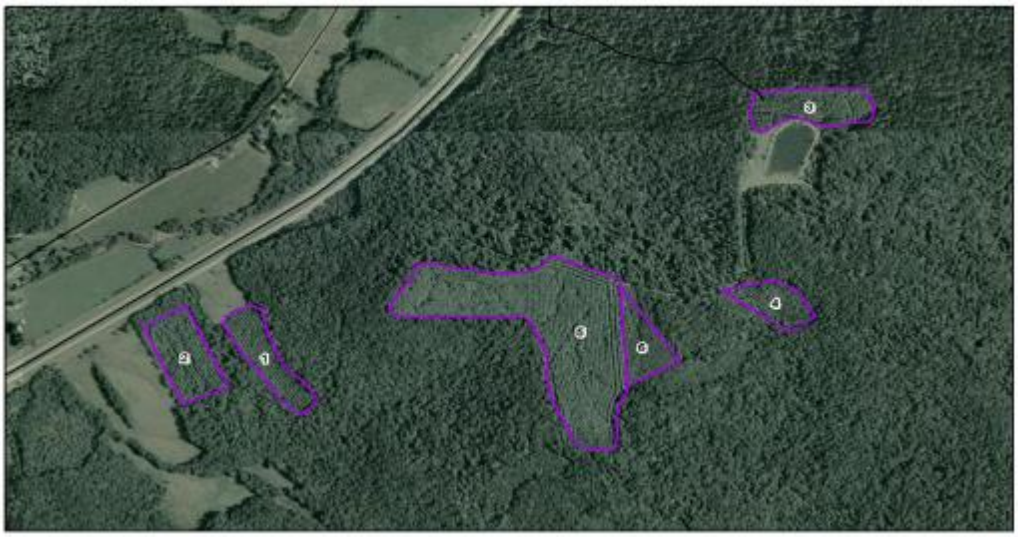
The Willis White Pine Plantation is in Adams County, Ohio seven miles northeast of Peebles, just off State Route 32 in the Brush Creek State Forest (Fig. 1 and 2). The plantation is owned by the Willis Lumber Company and was established in 1987. It consists of five individual plantations of eastern white pine (*Pinus strobus* L.), and one of Virginia pine (*Pinus virginiana* Mill.) comprising approximately 80 acres. The eastern white pines were planted on an eight-by-eight foot spacing (681 trees per acre). In three of the five white pine plantations a thinning was implemented in 2003. This thinning consisted of the removal of every third row across the plantations. Plantation five is currently under contract in the United States Department of Agriculture, Conservation Reserve Program (CRP). These plantations were established to generate timber revenue for the Willis Lumber Company. Stands one, two and five (thinned) were sampled for this project.

Project Objectives:

The objectives of this biological evaluation were to: (1) assess the populations and impacts of the pine bark adelgid (*Pineus strobi L.*) within each plantation; (2) investigate possible cause(s) of white pine mortality occurring across the plantations; (3) determine if there is enough merchantable timber for the landowner to implement a financially feasible timber harvest within the next three years; and (4) determine the approximate rate of mortality in order to assess the urgency of a timber harvest in the near future.

Figures 1 and 2: Willis White Pine Plantation, Brush Creek State Forest.





Project Methods:

In July 2010, plantations one, two and five were surveyed using 10 foot wide strip cruises. Because the stands varied in size from 7 to 38 acres, sampling was proportional to size. In total 13 strips were surveyed across the three plantations. The strips were spaced approximately 350 to 400 feet (5-6 chains) apart and were perpendicular to the thinning (stand 5). The starting point for each strip cruise was found using a global positioning system (GPS) unit, a compass bearing was shot from the boundary of the stand and a hip-chain was used to mark the center of each strip. All trees that fell within five feet on each side of the centerline were included in the cruise. Within each strip, species, diameter at breast height (DBH), total and merchantable heights, crown class, status and presence of PBA were recorded for all standing trees. Tree status was based on a five-point condition class system, ranging from healthy and alive to dead in excess of five years (Table 1). Levels of PBA were recorded based

on a four level classification system; (1) none; (2) light; (3) moderate; and (4) heavy based on the amount of white cottony material present on trunks and limbs.

Table 1: Dead and dying white pine condition class based on retention of needles and branches, Willis Lumber Company, white pine plantation, Brush Creek State Forest.

Status	Code	Estimated time since death*
1	Alive/Healthy	--
2	Fading/dying	current
3	Dead with needles	1-2 yrs
4	Dead with fine branches	>2-5 years
5	Dead with large branches only	>5 years

*Derived from Forest Inventory and Analysis guidelines (USDA 2001)

Data analysis:

We first compiled the observations on PBA, tree status, crown class and amount of merchantable timber across each stand. We opted for a more parsimonious statistical model and pooled the data from each stand and considering the presence of PBA and tree status as binary response variables. To investigate the association of crown position with tree status, we used contingency analysis in PROC FREQ (SAS Institute 2002) to analyze the frequency of dead to living trees by crown class, and by the presence of PBA (Stokes et al 2000). If a significance association was detected at $\alpha = 0.05$, we conducted post hoc tests by partitioning G^2 into non-significant components, and calculating odds ratios between significant components (Agresti 1996). We used analysis of variance (ANOVA) to determine the effects of the presence of PBA on height, diameter growth and crown class and interactions. Significance of effects was assessed using type III sum of squares in PROC GLM (SAS Institute 2002).

Project Results:

Mortality and merchantable volume

Overall, mortality was low across the three plantations. The average number of dead trees per acre varied by stand with an overall average of 23 trees per acre or about eight percent, comprising an average loss of 6.4 square feet of basal area per acre (Table 2). We observed a trend between mortality and trees per acre, with the lower stocked plantation having the lower mortality level and the higher stocked plantations higher mortality levels.

Table 2: Average basal area (BA) and trees per acre (TPA) and standard deviation by stand for living and dead trees, Willis Lumber Company, white pine plantation, Brush Creek State Forest.

Stand #	Mean Stand Diameter (in.)	TPA Live	BA/AC Live	TPA Dead	BA/AC Dead
1	8.6 ± 1.9	281 ± 153	121 ± 67	15 ± 4	4 ± 2
2	10.1 ± 2.7	181 ± 72	105 ± 42	4 ± 7	0.2 ± 0.4
5*	8.4 ± 2.1	357 ± 104	155 ± 50	51 ± 34	15 ± 11
Average	**9.03**	**273**	**127**	**23**	**6.4**

*Thinned in 2003

A significant difference in mortality was detected by crown position ($P \leq 0.01$). Dominant, codominant and intermediate trees were not significantly different in mortality levels ($P=0.12$), which as a group were significantly different from suppressed trees ($P \leq 0.01$). Suppressed trees were 10.6 times (95% CI=1.1-100) more likely to show mortality than intermediate, codominant and dominant trees.

Average height growth for six of the dominant trees in the plantations was 57 feet, giving a site index for the plantations of 65 (Vimmerstedt 1962). Mean stand diameter ranged from 8.4 to 10.1 inches (Table 2.) Comparing the mean stand diameters to stocking tables (Philbrook et al. 1973) all three stands are considered significantly overstocked.

The three plantations had an average of 3,567 board feet per acre, amounting to about 140 MBF of sawtimber (Table 3). There was a considerable amount of pulpwood volume across the plantations, averaging 16.1 cords/per acre, with just under 990 cords. Stand 2 had the highest board foot volume per acre, and stand 5 had the most cords per acre (Table 3). However, stand 5 consisted of the largest volume, comprising just over half the sawtimber volume and over three-fourths of the total pulpwood volume.

Table 3: Merchantable volumes for sawtimber and pulpwood, Willis Lumber Company white pine plantations, Brush Creek State Forest.

		Merchantable Volume		
Stand #	**Acres**	**Bdft/AC**	**Cords/AC**	**Tons/AC**
1	7	2599	17.8	47.6
2	8	6168	9.8	26.2
5	38	1934	20.7	55.4
Average		**3567**	**16.1**	**43.1**

Pine bark adelgid

Pine bark adelgid (PBA) was found widely across all three stands. Stand 1 had the highest percentage of trees showing PBA (Table 4) with nearly 95 percent having some level of adelgid infestation. Across all stands the adelgid was prevalent at the light level of severity, with few trees showing moderate and high severity levels. Approximately one-third of all trees sampled did not have PBA.

Table 4: Percentage of trees with Pine Bark Adelgid (PBA), Willis Lumber Company white pine plantations, Brush Creek State Forest.

Stand #	None	Light	Moderate	Heavy
1	5.5	90.9	0	3.6
2	40.6	50	9.4	0
5	36.5	59.5	1.6	2.3
Average	27.5	66.8	3.7	1.9

A significant difference in presence of PBA was detected between dead (fading/dying) and living trees ($P \leq 0.01$). Trees without adelgid were 6.7 times (95% CI=1.6-27.2) more likely to die then trees with adelgid. There were no significant differences among diameter growth ($F = 3.18$; df = 1, 474; $P = 0.0754$), height ($F = 0.33$; df = 1, 473; $P = 0.5640$) and presence of PBA, nor significant interaction effects ($F = 1.29$; df = 2, 472; $P = 0.2759$; $F = 0.05$; df = 2, 471; $P = 0.9541$).

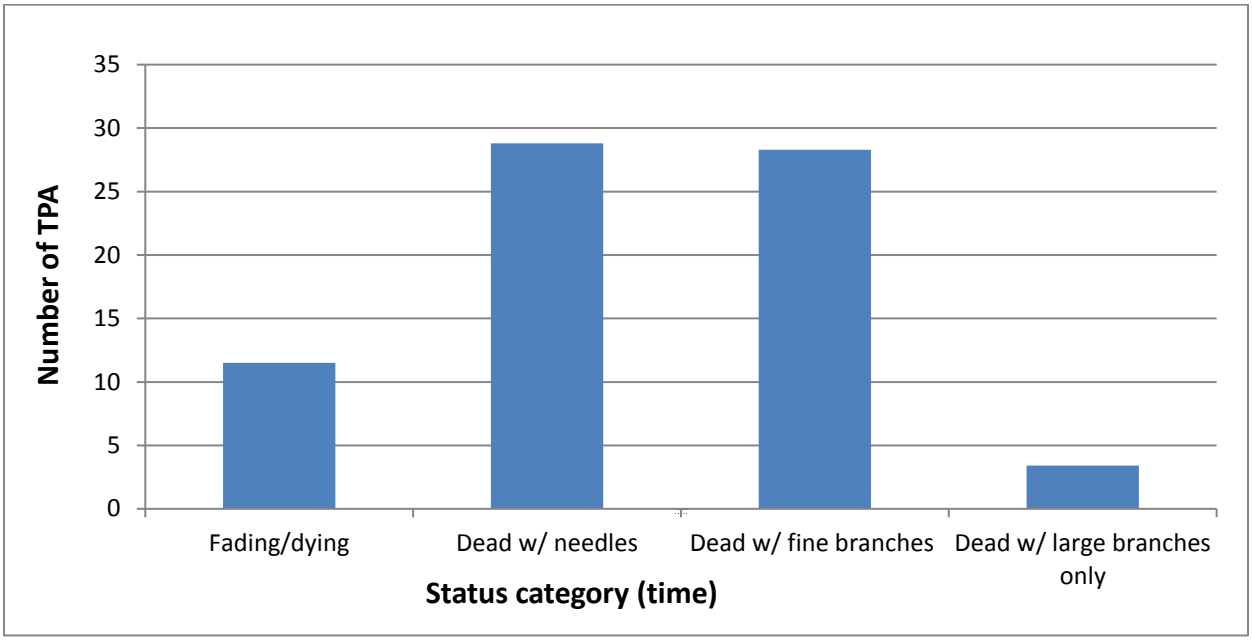
Rate of mortality

Rates of mortality defined by tree condition class peaked two to five years ago (Fig. 3); with the majority, 72 percent of mortality present coming from stand 5 (Table 2). This mortality coincides with the thinning that occurred in this stand in 2003. Older mortality defined by trees lacking fine branches was low, approximately six percent across the stands with most trees standing on an eight foot or less spacing (Fig 7).

Discussion:

Since one of the main objectives of this evaluation was to assess the presence and impact of the PBA on the Willis white pine plantation, it is important to know and understand this insect's biology (see additional information section). It is highly unlikely that pine bark adelgid is having a significant impact to the white pine plantations. No detectable difference was found in mortality, health or growth between infested and uninfested trees.

Figure 3: Number of TPA for dead and dying trees in each status category across stands 1, 2, and 5, Willis Lumber Company, white pine plantations, Brush Creek State Forest.



Mortality however, is occurring across all stands. This is most likely due to overstocking, spacing, soil drainage (Fig. 4) or for stand 5, potential compaction and root system damage related to the thinning in 2003 (Fig. 7). All of these were observed within the Willis white pine plantations and are potential causes of the observed mortality. It was observed that in some areas of the stands the tree spacing was less than five feet apart. It is recommended trees should be planted at 10' by 10' or even 12' by 12' in order to produce the highest board foot volumes across the plantation, or if planted at a closer spacing a pre-commercial thinning should be implemented based on stocking (Lancaster and Leak 1978).

The Willis white pine plantation had previously implemented a third-row thinning operation seven years ago. This operation included removing one entire row out of three. With this, there was likely tree damage caused by the machinery used to remove the rows. This likely damaged the root systems of the remaining trees, which effects were observed by the increase in mortality in stand 5 over the last few years. Another possibility is that the equipment used for the thinning might have compacted the soil causing drainage issues.

Ice storm damage was observed across all of the plantations. This appears to have occurred within the last five years. Because of this storm, many of the dominant and co-dominant trees were damaged. Branches comprising the crown were snapped off and in some cases the entire top was broken off. This was apparent across stand 5 by the observation of crooked tops (Fig. 5). This, compounded with presence of PBA, damage from previous thinning, and poor drainage capability all impact tree health and vigor.

Figure 4: Deep ruts and pools of water located in stand 5, between rows of trees possibly representing compaction and poor soil drainage capability, Willis white pine plantation, Brush Creek State Forest.

Based on the mortality data collected across stands 1, 2, and 5 it appears that the majority of the mortality has occurred within the past two to five years (Fig 6). It appears that recent mortality has slightly decreased, but there is no correlation between the mortality and the current infestation of pine bark adelgid. It is difficult to predict the current trend of mortality, but it is probable that the mortality rate will continue based on stocking and hover somewhere between 5 and 20 TPA for the next couple years.

Figure 5: Ice damage on a Dominant/Co-Dominant eastern white pine, Willis Lumber Company, white pine plantations, Brush Creek State Forest.

Figures 6 and 7: Mortality observed in stand 5 and a thinned row with slash piled in between two present rows with significant ruts in soil, Willis Lumber Company, white pine plantations, Brush Creek State Forest,

Management Alternatives:

Three management options have been evaluated for the Willis white pine plantation. These alternatives were determined based on the following objectives: 1) maximizing timber yields and income and 2) conserving white pine timber resources.

Alternative 1: No Action now, harvest later

This alternative is considered the environmental baseline (no action alternative). Under this option, no silvicultural treatments are implemented and nature is allowed to run its course. The stand is simply left to produce timber yields strictly on a natural basis. Stands will remain crowded and mortality will continue to be present, with the potential of increasing over time. Stressed stands will likely see an increased susceptibility to insect and disease outbreaks. Individual tree DBH and crown growth will remain suppressed with growth ranging from poor to moderate on smaller crowned trees and from moderate to high with larger crowned trees as the plantations self-thin.

Alternative 2: Implement a pre-commercial thinning by removing one out of every three trees in each row.

This involves removing one-third of all trees and approximately one-quarter of the total basal area. In each row, one tree would be removed from the first three trees, one from the next three, and so on, all the way to the end of the row. The trees selected to be harvested should be the least desirable (smallest DBH, smallest crown, insect or disease infested). Thinning such as this will reduce densities across the stand and accelerate crown and DBH growth on desirable trees. Selected trees to be harvested will need to be marked. Felling and removal of the trees will be difficult due to the fact that row thinning was already implemented on the stands. Conventional skidders would be too large for this type of thinning operation so girdling or herbiciding could be used. After implementing the thinning, wait ten to fifteen years to harvest the residual trees.

Alternative 3: Clear-cut all stands now and replant.

This alternative is a drastic approach and quite extreme. The aesthetic value of the stand would be non-existent and the land owner would be left with the question of what to do next. If he chose this option, he should wait until the end of his current contract and implement the harvest at that point in time. Under this alternative, there is the risk that undesirable species, including fern and greenbrier would invade the property and prevent seedlings from successfully regenerating. It may be necessary to apply herbicide to control the undesirable species until the desirable species have become successfully established.

Recommendations:

Since mortality rates are currently low, it is recommended that if any of the above alternatives are chosen that they should be implemented after the two-year CRP contract has ended. Alternative 1 will continue to have mortality occur due to poor conditions, including overcrowding, poor drainage, and potential damage from a previous thinning operation. Also, there is an increased chance for an insect or disease infestation if no action is taken. Alternative 3 isn't recommended due to the fact that the stands are not financially mature yet. Even though considerable money will be generated from the stands, they won't be yielding maximum revenue yet. With this option, you also have to consider the aesthetic value of the land after the clear-cut. Alternative 2 will increase the overall tree vigor and tree growth across the plantation and allow the stands to reach a point where they will sustain maximum yields. This alternative maybe difficult to implement based on stand age and the landowner will incur a cost with this alternative.

It is recommended that the landowner decide in favor of Alternative 2. This will provide the landowner with an increase in individual tree health and overall health of the stands across the plantation, while allowing the stands to reach a financially mature age maximizing timber yields. The following practices are recommended during logging or thinning operations: 1) use as much of each tree as possible and avoid leaving debris in or near the stand, 2) remove harvested trees and infested (fading/dying) trees from the stand as soon as possible, and 3) minimize the damage to remaining trees and roots by equipment and felling (Conner and Wilkinson 1983).

Additional Information

Pine Bark Adelgid

Adelgids are small, soft-bodied insects that feed on plant sap. The family is divided into two genera: *Adelges* and *Pineus*. Members of this family feed exclusively on conifers. There are sixteen species of adelgid found within this family, of which seven are native to North America.

Pine bark adelgid (*Pineus strobi* (Hartig)) belong to the genera *Pineus* and appear to be indigenous to Eastern North America (Drooz 1989, Montgomery 1999). The pine bark adelgid (PBA) is widely distributed in North America, occurring throughout the native range of eastern white pine. The primary host of the insect is the eastern white pine (Pinus strobus), but it can also be found on Scots and Austrian pines. The pine bark adelgid is covered with a white wax and feeds by sucking sap from the tree. Infestations are recognized by the presence of spots and patches of white cottony material on the bark of trunks and limbs, on buds, or at the bases of needles. On older trees the infestation is unsightly and mortality will usually not occur. However, if heavily infested, younger trees can become discolored, stunted or weakened, and death may occur. Adults are small, purplish to yellow, and covered with white strands of wax. Nymphs (immature) resemble adults except for their smaller size (Hale et al. 2010).

Pine bark adelgid overwinter in all stages, but usually as immature females. Development continues in late winter and eggs are laid in the spring. Winged individuals will migrate to other trees and begin feeding. Wingless forms remain feeding on the tree and reproduce repeatedly. There are multiple generations per year (Hale et al. 2010).

Eastern White Pine

Eastern white pine was once considered the single-most important timber species in North America and is still considered one of the most valuable timber species today in Eastern North America. The native range of eastern white pine ranges from southern Canada all the way to extreme northern Georgia and as far west as Minnesota (Wendel and Smith 2010). White pine

grows best on well-drained sandy soils of low to medium site quality. Poorly drained and heavy clay soils are not suitable for white pine.

Figures 3 and 4: Presence of pine bark adelgid on the bark of eastern white pine, Willis white pine plantation, Brush Creek State Forest.

Improvement in stand quality can be obtained with an appropriate, well-timed thinning. The decision of when to thin is directly linked to the number of trees per acre planted. If fewer than 400 TPA are planted, then a 30 to 40 year rotation with no thinning should produce logs demanded by most markets (Clatterbuck and Ganus). If TPA planted exceeds 400, then a thinning should be implemented. Often, it is best if the thinning produces small logs for log homes or for pulpwood where markets for paper and engineered wood panels are available (Clatterbuck and Ganus). The decision to thin and when to thin is less difficult if these circumstances exist.

Another effective practice to improve the quality of a white pine stand is pruning. White pines self-prune naturally as they compete for space, however dead branches can still exist for several years after. Pruning of the side branches eliminates this undesirable characteristic. If you choose to prune, only prune the larger trees that will remain until final harvest. It is recommended that you should prune after the first thinning and to a height of 17 feet on trees no larger than 7 inches in diameter (Clatterbuck and Ganus). This helps to ensure that wounds from pruning are adequately covered by clear wood before final harvest.

A total of 277 insects and 110 disease organisms are known to attack white pine, however only 16 insects and 7 diseases cause significant injury or mortality (Wendel and Smith 2010). Protecting white pine from these damaging agents in the northeastern United States often requires intensive management. However, with proper site selection and silvicultural

management white pine can usually be grown with limited pest management. The major threats to white pine are the white pine weevil and root declines (Clatterbuck and Ganus). Other threats are various root rots, white pine adelgid (leaf and bark adelgid), and white pine blister rust. These can all be potential serious problems and if you are growing white pine it is imperative to be familiar with these pests. Another potential problem with white pine is fire. The bark is very thin and can easily be damaged or killed by a fire. It is recommended that fire breaks and lanes should be implemented across the plantation (Clatterbuck and Ganus).

Below is a table representing a calendar of silvicultural practices. This includes individual recommended management practices and the appropriate time to implement them. For more additional information on management of eastern white pine plantations, you can access the site:

http://utextension.tennessee.edu/publications/Documents/PB1462.pdf

Table 5: Calendar of Silvicultural Practices for eastern white pine.

WHAT	**WHEN**
Prescribed burning	Spring or fall before planting
Site preparation and sub-soiling (if needed)	Fall before planting
Buy seedlings	At planting
Plant seedlings	December to March
Weed control	First 3 years after planting in early spring
Protect from fire	Continuously
Protect from livestock grazing	Continuously
Fertilize	After first thinning
Prune	Early spring after first thinning
Pest control	Early spring
Harvesting - thinning	once between ages 25 to 35
Harvesting - final	between ages 30 to 40

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Additional information available on the internet:

http://ohioline.osu.edu/for-fact/0035.html
http://utextension.tennessee.edu/publications/Documents/PB1462.pdf
http://www.utextension.utk.edu/publications/spfiles/SP290-O.pdf
http://www.na.fs.fed.us/pubs/silvics_manual/volume_1/pinus/strobus.htm